Integrating Health Information Systems into a Database Course: A Case Study

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Abstract

Computer Science is a rich field with many growing application areas, such as Health Information Systems. What we suggest here is that multi-disciplinary threads can be introduced to supplement, enhance, and strengthen the primary area of study in a course. We call these supplementary materials *threads*, because they are executed alongside the material presented in the course, reinforcing and augmenting it but not replacing it. Many studies have been performed on how making a topic more meaningful and relevant to students can improve their outcomes. Integrating Health Information Systems into the Computer Science curriculum can achieve this. In this paper, we present a case study in which the development of a health system is integrated into a Database course. The results indicate that students enjoyed the course more, were more motivated to complete the course project, and were able to learn and apply the core course materials more readily.

Keywords: multi-disciplinary, health information systems, threads, database, curriculum

1. INTRODUCTION

Computer Science (CS) is a field that is poised to grow in the foreseeable future, with lucrative job opportunities and interesting application areas. Even though the future is bright for Computer Science majors, many leave the major to pursue other career paths. "Rising crescendos of voices sound alarm about the sharp downturn in young people selecting a computing field for their careers…Finding people to fill the growing number of IT jobs will soon be more difficult than ever (Denning & McGettrick, 2005)." One reason suggested for this migration is a lack of knowledge or interest in the areas where CS skills can be applied.

The Association for Computing Machinery (ACM) has launched several initiatives to reverse the trend, including endorsing "experiments to find curriculum formulations that express better what

computing is about and are more appealing (Denning & McGettrick, 2005)."

The case study presented here helps to support this idea of expressing what computing is about – why it is valuable and where it can be applied to benefit society. In this case, the path we take toward this goal is in merging the introduction of Computer Science topics, specifically database systems topics, with the quickly emerging field of Health Information Systems (HIS). Health Information Systems is an area that is currently growing and flourishing and is in need of skilled technical contributors. Recently, the US government has provided significant funding towards efforts in this area as well as emphasized patient safety and high-quality medical care initiatives (Cantrill, 2010). Data mining and analysis are being done on medical data that assist in treatment and advances in medicine. Greater progress can be made as computer scientists work together with doctors, researchers, and statisticians to record and utilize medical data appropriately.

What we propose here is the integration of Health Information System topics within a database design course. We present a case study of a HIS project that was integrated into a second-semester database course. In this course, the project was integrated to reinforce all of the concepts typically addressed in this type of course. Instead of utilizing a fabricated set of requirements, this work was done with a real set of HIS requirements produced by the Biomechanics and Motion Analysis Research Lab at the Mayo Clinic Rochester. The results were positive in that a system was produced, polished, and is now utilized by the lab. More important, the students were intrigued and invested in the project. This was clearly indicated by the improved learning outcomes. In this paper, we present details of the collaboration and its outcomes.

2. HEALTH INFORMATION SYSTEMS

First, let's examine Health Information Systems and the need for Computer Science contributors. Health Information Systems are systems used by the health care community that deal with managing health related information. Reichertz points out the "need for education in health informatics and/or biomedical informatics, including appropriate knowledge and skills on HIS. (Reinchertz, 2006)" In a recent CACM article, Cantrill points out that "there are many potential advantages from the application of health information technology (or HIT, the current buzzword). These include improved communication between a single patient's multiple health-care providers, elimination of needless medical testing, a decrease in medical errors, improved quality of care, improved patient safety, decrease paperwork, and improved legibility. (Cantrill, 2010)" The movement toward creation and adoption of these types of systems in the health care environment has many challenges. The systems are complex, and evaluation of the systems is difficult (Ammenwerth, Graber, Herrmann, Burkle, and Konig, 2003). Success is often elusive, with improper communication between those developing the systems and the end-users (Tan & Hallo, 2008).

It is interesting to note that when compared with other industries, health care is significantly behind in adopting information technology (Goldschmidt). Goldschmit believes that "Health Information Technology combined with the Internet is expected to foster patient-focused care, to promote transparency in prices and performance, and to enable consumers to drive the transformation of the health care system." These are formidable goals.

3. THE PROJECT

The integration of HIS as a thread in this course was achieved primarily through a semester-long project. The project in this course was a collaboration between the university and the Mayo Clinic's Biomechanics and Motion Analysis Lab. The Lab needed a database and web application that would allow them to record, query, and analyze patient data, both for the research and for clinical aspects of the lab. Eighty percent of the work they do is for research, with the remaining twenty percent for clinical work. Their problem was a common one in research-intensive labs. They have a large data set, and they would like to have the ability to utilize this data for their research goals. However, they do not have the technical staff or the technical knowledge to produce a system to achieve this. For example, clinical decision support systems can be introduced to improve patient outcomes (Hunt, Haynes, Hanna, & Smith, 1998). Initial data recording and analysis is a first step toward this goal.

A Kinesiologist from the Lab was in contact with us about developing a computer software system to support their research and patient care. This type of project could be utilized to reinforce the key ideas of database design and development that we wished to present in the

course. It would also allow us to introduce the field of Health Information Systems, a growing application area for Computer Science. A partnership was formed, and development began. Requirements for their particular system were gathered, and database design alternatives were discussed in the context of the Lab's particular needs and specific data set.

The development of the project was done incrementally. It was partitioned into individual assignments that corresponded to the topics introduced in a more traditional manner throughout the course. But more life was breathed into the topics by having a real and interesting application area. The students came away with an understanding of key course concepts, the basic needs of Health Information Systems, and a real world project that sparked their interest. A description of overall course goals, as well as specific project goals and outcomes, are presented in the next section.

4. COURSE GOALS

Course goals included making students knowledgeable on core database concepts, along with the introduction of Health Information System concepts and team development experience.

Presentation of core knowledge was the number one goal of the course. Key concepts include the relational model, database design and normalization, interaction with a database from an application, and advanced database programming and security.

Additional learning surrounding Health Information Systems was a secondary goal. The discussion of HIS focused on its relevance to other course topics, and on how to apply database design techniques to HIS.

While team development was not a primary goal of the course, it was also a piece of the coursework. Team development proved to be of benefit in terms of student confidence, drive to complete the project, and growth of excitement in discussing the project.

In previous courses where team development was employed (and especially when an outside party was involved), we have utilized two different techniques. One approach was to use competition as a motivating factor. In past courses, teams of students were asked to produce solutions to the same problem. They were competing to produce the best solution. This often resulted in a very good solution by a subset of the teams. Some teams, however, became discouraged as they saw other teams developing more sophisticated solutions. They would eventually give up hope of having their solution "win", or be selected by the 3rd party in cases where outside organizations were involved.

An alternative approach is to have students cooperate to produce a single solution. Here, the job can be partitioned into multiple tasks that can be assigned to separate teams. As the tasks are completed, the resulting components can be integrated together. The benefit of this approach is that all teams contribute to and feel ownership of the final solution. This is actually a very "real world" approach.

However, there are several issues with taking the cooperative approach. First, it is only feasible with a project of fairly large scope, since there must be enough tasks to allow all to contribute. It requires a lot of organization and guidance from the instructor. Communication between teams needs to be increased. Learning communication skills is important for computer scientists, but it takes time away from learning the theory and technologies needed to complete the project. In addition, it can be difficult to include all of the desired course objectives into each team's portion of the project. Another key issue is when one team doesn't successfully deliver their portion of the project, and the final system is not completed successfully. This can be upsetting to the students, but it is more devastating to the client organization when one is involved.

A successful balance was achieved for this case study. The first part of the project involved the development of the database, which the class performed cooperatively. Many discussions were held regarding proper database design and normalization. These were key course concepts, and everyone was able to contribute and learn from this discussion. Output from this stage of the project included an entity- relationship model, which evolved into a normalized database schema.

In the next phase, groups cooperated in implementing the database tables and performing data entry. This was not done together as a class. Instead, pieces of the design were assigned to each group for implementation. This was not particularly difficult, nor did it require a lot of communication. It was fairly simple to construct

the final database using this divide-and-conquer strategy.

In the final phase, the application that communicated with the database was developed. Since we were working with a real Lab with critical data, we had to produce a solution that they could put into operation and would function successfully. For this phase, teams were asked to compete to produce the required application. The Lab would then select their preferred version to be utilized for live patient data storage and querying.

5. OUTPUT

Output from the project is similar to what you would expect to see from assignments given in a typical database course. In Figure 1, you can see the entity-relationship diagram produced for the initial design of the system. While most of the details are not significant for this discussion, you may find it interesting to note that some of the entities are common to many Health Information Systems. For example, you will usually wish to store data about patients, such as diagnoses and treatments they have received, as well as individual visits to the clinic/hospital. You will also see data specific to this Lab, such as assistive devices used by patients, and the video system used to record tests performed on the patients to measure different aspects of their strength and locomotion.

This ER diagram shown in figure 1 represents a high level view of the system. This must be fleshed out into an implementation level view. A database schema was next created by students to reflect the details. For example, below is the schema for the BillingCodes table.

BillingCodes(billingCodeID, visitCharge,
CPTCode, integerIncrement, visitID)
*visitID foreign key to visit(visitID)

The schema can be used to write *create table* statements, which define attributes, data types, and constraints (including primary keys and foreign keys). Once the tables are created, *insert* statements can then be written. To implement all of the DDL (data definition language) statements produced by the students, one needs to be conscious of the foreign key constraints, so that the tables are created in the proper order. (An alternative is to define the tables without foreign key constraints, and then write *alter table* statements to add these constraints.)

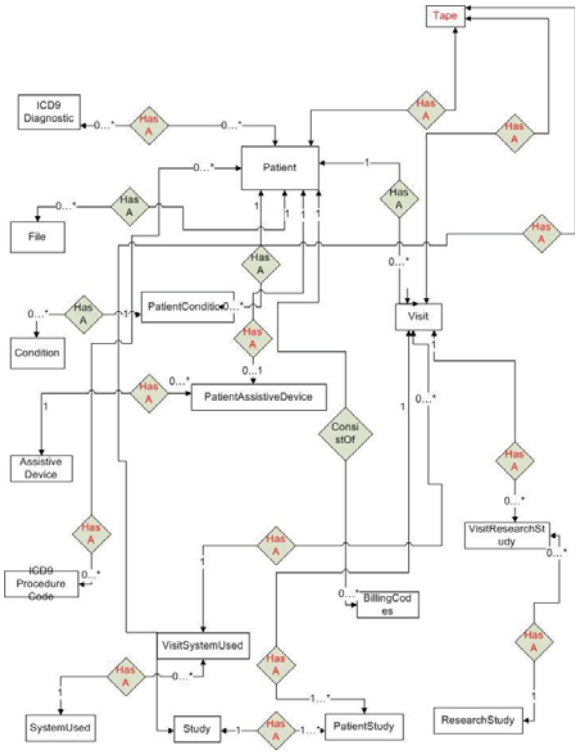

FIGURE 1: Motion Analysis Lab ER Diagram

The output described so far was produced during the cooperative phase of development. The competition phase followed to produce the application software that would sit on top of and connect to the database. The application would allow users to quickly and easily insert, view, and query the data to produce interesting results. Due to the nature of the project and the sensitivity of the data set, we cannot show the outcomes of this portion of the project here.

6. STUDENT FEEDBACK

Student feedback on the course was overwhelmingly positive. Much of the feedback focused on core course concepts. No students indicated that having a project like this one detracted from this core learning. Some general course comments included:

"I gained a much more complete understanding of how to design, implement, and maintain a database."

"I essentially went from not knowing anything about building this type of system to developing an entire site within the span of a month."

Many students commented on the project. They enjoyed working on something they considered real world, and they enjoyed being introduced to a new application area for their recently gained knowledge. Here are some of the comments on the project and on the integration of Health Information System concepts into the course:

"I'm really glad I learned this because it's one of those things I really enjoy and will likely pursue outside class, it's probably the single most favorite thing I learned all semester."

"The project was fascinating to me."

We certainly don't base our curriculum decisions primarily on whether or not students enjoy certain material. We do believe that, if they find the material interesting and relevant, they are more likely to put in the effort necessary to learn it well.

7. ADDITIONAL OUTCOMES

Some additional outcomes resulted from this collaboration. The key goal was to present course concepts in a relevant and motivating way by applying the concepts to the development of a Health Information System. We believe we achieved this goal. Grade outcomes in the course were slightly higher than in previous semesters, including on exams that were equivalent conceptually and not HIS-focused for either group. In addition, one student was hired to continue work on this development. Several students are continuing to pursue research related to Health Information Systems with the faculty involved in this project. Finally, the University and Lab are forging a long-term relationship that will result in continued collaboration. While these are not key goals, we feel they are important benefits that have come out of the collaboration.

8. CONCLUSION

Integrating multi-disciplinary threads into the Computer Science curriculum can increase interest in and relevance of the material for the students. In this case study, we integrated Health Information Systems into a database course though the use of sequential homework assignments, producing a database application for the Mayo Clinic's Biomechanics and Motion Analysis lab. Other areas such as Geographic Information Systems could be used with a similar goal. We believe the end result of this project will live on beyond the end of the semester, and will be even greater than just achieving the outcomes defined for the course. We expect, as a lasting benefit, increased retention of aspiring CS students when they discover Computer Science areas that they are truly passionate about.

Future work includes continuing to monitor emerging application areas in Computer Science nationally and in our community to facilitate additional connections and collaborations. We also plan to monitor the paths of students in this course to determine if a larger number remain in the field and if they are able to use the additional information gained on Health Information Systems in other ways.

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APPENDIX A – Complete ER Diagram